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(71) Applicant
Westland Helicopters Limited

(Incorporated in the United Kingdom)

Westland Works, Yeovil, Somerset, BA20 2YB,
 United Kingdom

(72) Inventor
John William Damon

(74) Agent and/or Address for Service
Westland Helicopters Limited
 Westland Works, Yeovil, Somerset, BA20 2YB,
 United Kingdom

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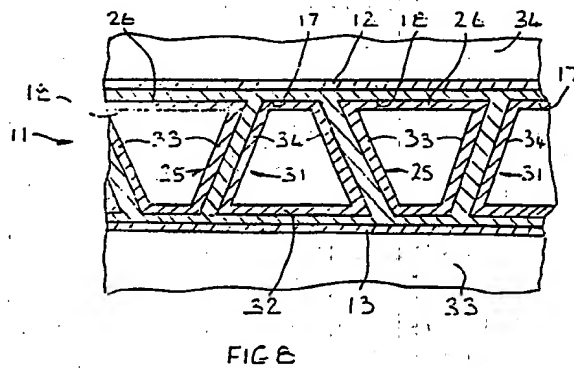
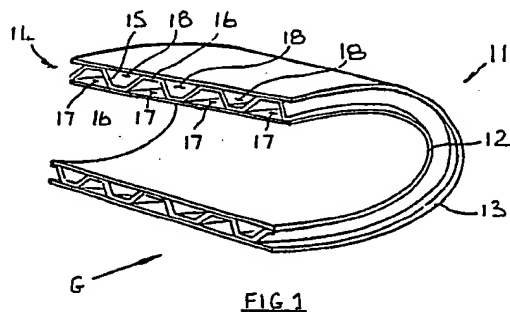
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 A2E4C A2E4DX A2E4K
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(58) Field of search
 UK CL (Edition J) **B5A AB11 AL1 AT11P AT9P**
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(54) Moulding a fibre reinforced composite, into a hollow structure comprising outer and inner skins connected by ribs

(57) The structure (11) preferably comprises a hollow leading edge aerofoil, in which the ribs (15) define passages (17, 18) for fluid circulation in use. The composite is wrapped around hollow mould tool parts (25, 31) which are nested together between inner and outer composite skins (13, 12) within external mould tool parts (33, 34), and moulded under heat, and pressure which may partly be applied by internal pressurisation of the hollow mould tool parts, which may be of aluminium and may be removed from the cooled structure by etching. The composite is preferably fibre reinforced thermoplastic. The ends of the hollow mould tool parts (25, 31) may be rectangular, to provide aerofoil end regions for support and attachment of trailing edge skins, and attachment of fluid circulation supply means.



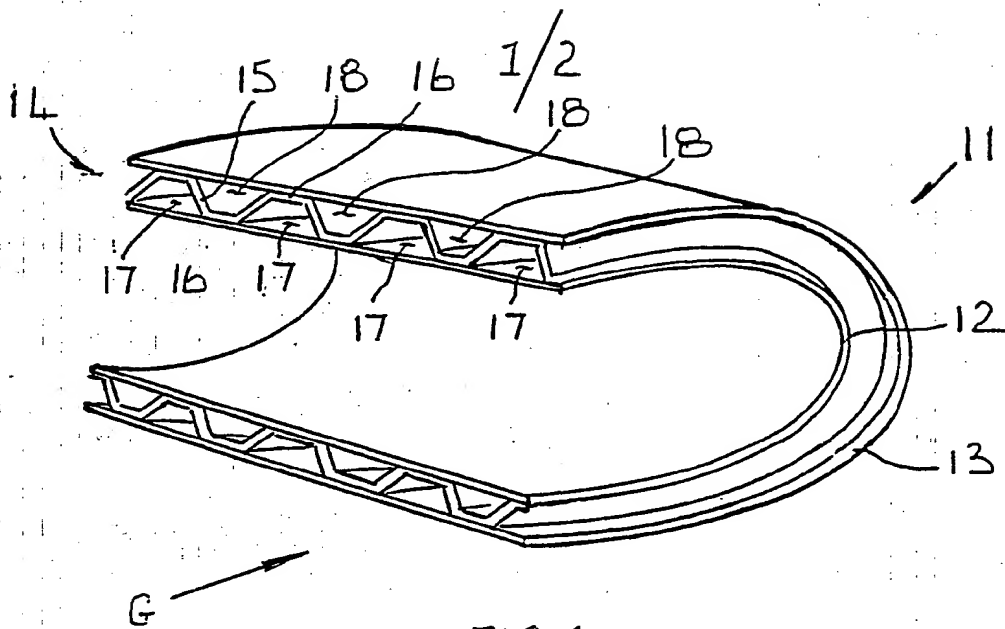


FIG 1

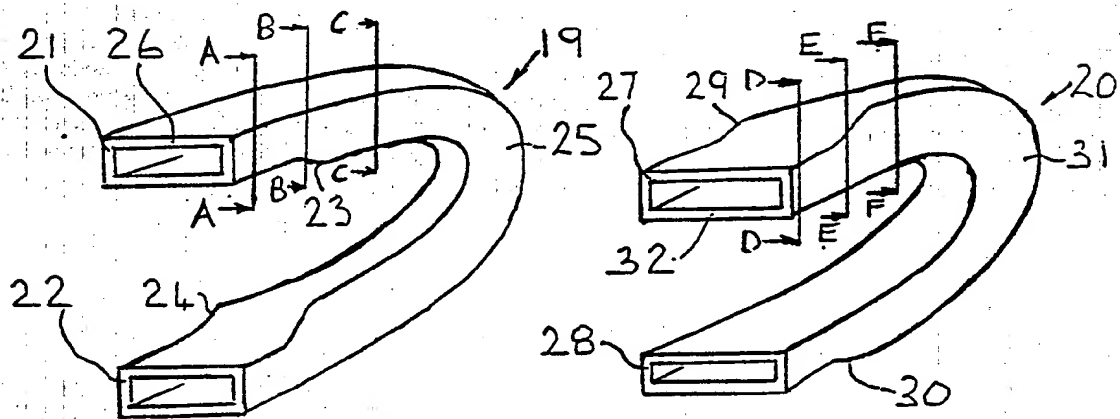


FIG 2

FIG 3

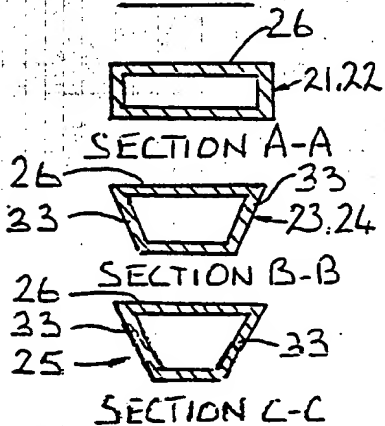


FIG 4

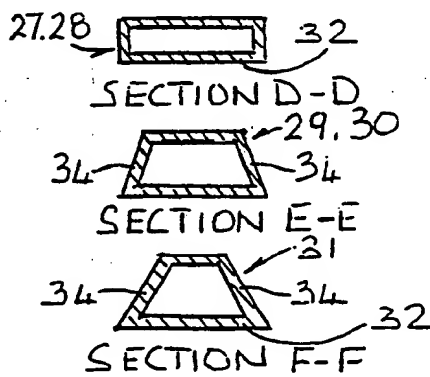


FIG 5

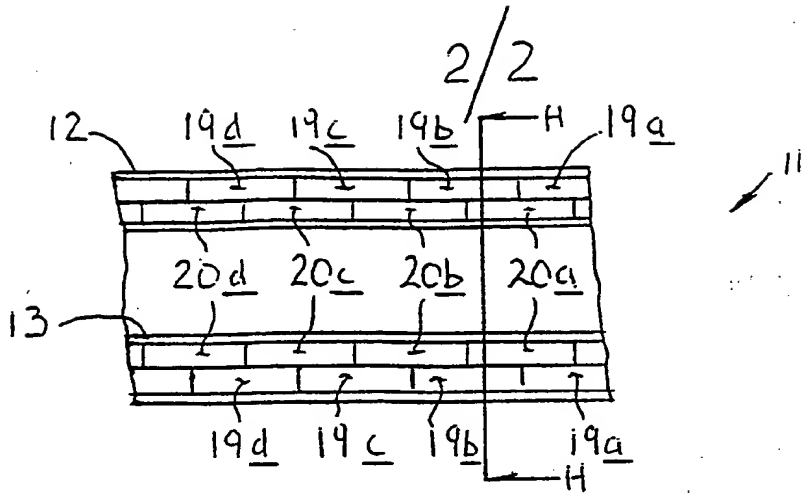


FIG 6

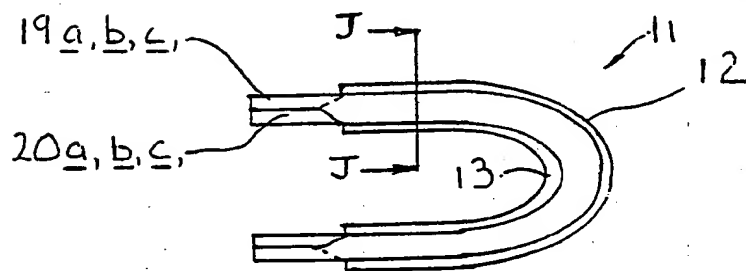


FIG 7

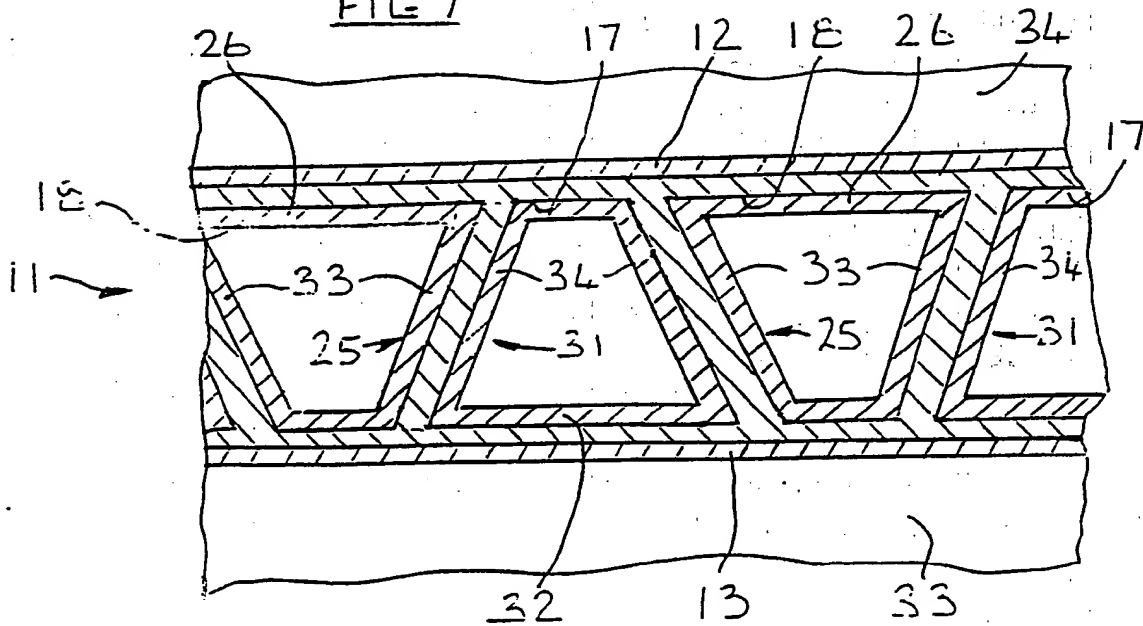


FIG 8

Description of Invention

Title: Method for Manufacturing a Hollow Structure

This invention relates to a method for manufacturing a hollow structure and is particularly concerned with a method for manufacturing a hollow leading edge aerofoil structure.

Both thermosetting and thermoplastic fibre-reinforced materials are now widely used in industry due to their ability to be readily formed into complex shapes by moulding. The very good strength to weight ratios of such composite materials has attracted the attention of the aircraft industry and composite materials are now widely used in the production of structural components and aerofoil structures both for fixed and rotary wing aircraft.

There is a requirement in the aircraft industry for a composite hollow aerofoil leading edge structure having chordwise extending ribs defining fluid tight channels through which a desired fluid can be passed during operation. Such a structure has heretofore proved extremely difficult to manufacture.

Accordingly, this invention provides a method for manufacturing a hollow structure of composite material and having inner and outer skins joined by rib portions comprising the steps of:

- wrapping a desired thickness of composite material around a plurality of mould tool parts,

- nesting the mould tool parts together between inner and outer composite skins so as to form the interconnecting webs,

- locating the assembly in a mould tool,

- curing the assembly and removing from the mould tool, and

- removing the mould tool parts.

The mould tool parts may have complementarily changing cross sectional shapes throughout their length which may include central regions providing the appropriate configuration for forming the rib portions.

The mould tool parts may comprise first and second mould tool

parts nested end-to-end in at least two stacked rows and in overlapping relationship to each other.

The central regions may have a cross sectional shape having sloping converging side surfaces extending away from a planar surface extending throughout the length of the tool part. The planar surface of the first tool part may correspond to an external surface of the structure and that of the second tool part may correspond to an internal surface thereof.

The or each mould tool part may be curved throughout its length to provide a curved hollow structure.

Preferably the mould tool parts are hollow and are constructed of aluminium to permit removal from the cured assembly by etching.

In another aspect the invention provides a method for manufacturing a hollow aerofoil shaped leading edge structure comprising spaced-apart inner and outer skins joined by chordwise extending rib members forming individual chordwise extending channels, characterised by the steps of:

preforming a plurality of first outer mould tool parts and a plurality of second inner mould tool parts,

wrapping a desired thickness of composite material around each of the first and second tool parts,

locating a composite inner skin on an external part of a mould tool,

nesting the inner mould tool parts end-to-end on said inner skin,

nesting the outer mould tool parts end-to-end on the inner mould tool parts and in overlapping relationship with said inner parts, whereby complementarily shaped parts of said inner and outer mould tool parts combine to form said joining rib members,

locating the outer composite skin on said outer mould tool parts,

heating the assembly and closing the mould tool,

allowing the mould tool to cool to form the structure,

removing the structure from the mould tool, and

removing the mould tool parts from within the formed structure.

The invention will now be described by way of example only and with reference to the accompanying drawings in which,

Figure 1 is a fragmentary perspective view of a hollow aerofoil leading edge structure,

Figure 2 is a perspective illustration of a first mould tool part used in the construction of the structure of Figure 1 and in a method according to this invention,

Figure 3 is a perspective illustration of a second mould tool part used in the inventive method,

Figure 4 comprises three sectioned views taken on lines A-A, B-B, and C-C of Figure 2,

Figure 5 comprises three sectioned views taken on lines D-D, E-E and F-F of Figure 3,

Figure 6 is a schematic illustration taken in the direction of arrow G of Figure 1 modified to show the location of the assembled first and second mould tool parts,

Figure 7 is a sectioned view taken on lines H-H of Figure 6, and

Figure 8 is a scrap sectioned view taken on lines J-J of Figure 7 illustrating features of the method of the invention.

Referring now to Figure 1, a hollow aerofoil section 11 suitable for use as the leading edge of a fixed or rotary wing is constructed of thermoplastic composite materials. Spaced-apart inner and outer skins 12 and 13 respectively are supported by chordwise extending ribs generally indicated at 14 comprising sloping wall portions 15 joined by flat land portions 16 bonded alternately to the inner and outer skins 12 and 13.

The sloping wall portions 15 define alternate chordwise extending channels 17 and 18 which during operation may be connected to a source of fluid. As shown in Figure 1 the walls 15 of channels 17 converge towards the outer skin 12 and the walls 15 of channel 18 converge towards the inner skin 13.

Figures 2 and 3 illustrate first and second mould tool parts 19 and 20 respectively each comprising a hollow thin walled preformed aluminium mould. In operation a plurality of first mould tool parts 19 are used to form channels 18 of Figure 1 and a plurality of second mould tool parts 20 are used to form the alternate channels 17.

Referring now to Figure 2, first mould part 19 comprises upper and lower end regions 21 and 22 of generally rectangular cross sectional shape joined via upper and lower transition regions 23 and 24 by a central region 25.

As shown in Figure 4, the cross sectional shape of the first mould

tool part 19 changes from the rectangular shape of end regions 21 and 22 gradually in the transition regions 23 and 24 where side walls 33 slope inwardly and the depth of the section is increased into the cross sectional shape of the central region 25 where the side walls 33 slope further inwardly so that the depth of the section is further increased to correspond to the internal shape of the channels 18 of Figure 1. It will be noted that a planar external surface 26 of mould tool part 19 remains constant throughout its length and that the side walls 33 converge as they extend from the surface.

Figure 3 and 5 provide details of the second mould tool part 20 which likewise has generally rectangular end regions 27 and 28 joined through transition regions 29 and 30 to a central region 31 having a cross sectional shape which corresponds to the internal shape of the channels 17 of Figure 1. In the second mould tool part 21, a planar internal surface 32 remains constant throughout its length and side walls 34 again converge as they extend from the surface.

As shown in Figures 6 and 7 and ignoring for the moment the necessary provision of the fibre-reinforced thermoplastic material from which the structure 11 is to be produced, a plurality of the first mould tool parts 19a, b, c, d, etc. are located end-to-end within the outer skin 12 and a plurality of the second mould tool parts 20a, b, c, d, etc. are located end-to-end internally of the first tool parts 20 and in an overlapping relationship. The internal skin 13 is located internally of the surface 32 of the second mould tool parts 21.

In the production of the structure of Figure 1 according to the method of this invention, the individual first and second mould tool parts 19 and 20 are wrapped throughout their length with a number of sheets of fibre-reinforced thermoplastic material until the required thickness is obtained. Sheets of fibre-reinforced thermoplastic material forming inner skin 13 are similarly laid on an external surface of a mould tool 33 and the wrapped tools 19 and 20 are nested together and over inner skin 13 as shown in Figure 6 and Figure 8. The outer skin 12 comprising a number of sheets of fibre-reinforced thermoplastic material is laid over the nested first and second tool parts 19 and 20. It will be understood that in the aforementioned lay-up procedure it may be necessary to apply heat locally to the individual sheets of fibre-reinforced thermoplastic material to assist

in forming the sheets to the required profiles. The assembly is heated as the tool is closed by external tool part 34 to apply a consolidating pressure in conventional manner to form the structure 11, and pressure is also applied internally of the first and second mould tool parts 19 and 20 to assist consolidation.

The assembly is allowed to cool to set the thermoplastic material and removed from the tool parts 33 and 34.

The first and second mould tool parts 19 and 20 are then removed by etching.

It will be apparent in the described method that the assembly includes protruding end regions because of the wrapping of the thermoplastic material around the end regions 21, 22 and 27, 28 of the first and second mould tool parts 19 and 20. These protruding end regions are useful in providing for support and attachment of the trailing edge skins (not shown) of an aerofoil assembly and for facilitating attachment of the aforementioned supply of fluid that is desired to flow through some or all of the channels 17 and 18 of structure 11. In that respect it will be noted that adjoining walls of the protruding end regions can easily be removed as required to provide communication between any desired number of the channels 17 or the channels 18.

Whilst one embodiment has been described and illustrated it will be understood that many modifications may be made without departing from the scope of the invention. For example, the nesting cross sectional shapes of the central regions 25 and 31 of mould tool parts 19 and 20 respectively can be chosen to provide alternative cross sectional shapes for channels 17 and 18. The mould tool parts 19 and 20 can be of uniform cross sectional shape throughout their lengths and can be simply nested end-to-end in a single row rather than the end-to-end overlapping inner and outer rows of the described and illustrated embodiment. The invention can be used in the manufacture of hollow structures from thermosetting fibre-reinforced materials.

CLAIMS

Patent Appln. No. 8828841.0
filed 09 December 1988

1. A method for manufacturing a hollow structure of composite material having inner and outer skins joined by rib portions comprising the steps of:

wrapping a desired thickness of composite material around a plurality of mould tool parts,
nesting the mould tool parts together between inner and outer composite skins so as to form the interconnecting webs,
locating the assembly in a mould tool,
curing the assembly and removing from the mould tool, and
removing the mould tool parts.

2. A method according to Claim 1, wherein said mould tool parts have complementarily changing cross sectional shapes throughout their length including central regions providing the appropriate configuration for forming the rib portions.

3. A method as claimed in Claim 1 or Claim 2, wherein said mould tool parts comprise first and second mould tool parts nested side by side in at least two stacked rows and in overlapping relationship to each other.

4. A method as claimed in Claim 2 or Claim 3, wherein said central regions in cross section include sloping converging side surfaces extending away from a planar surface extending throughout the length of the mould tool part.

5. A method as claimed in Claim 4, wherein the planar surface of each first mould tool part corresponds to an external surface of the structure and the planar surface of the second mould tool part corresponds to an internal surface of the structure.

6. A method as claimed in any preceding Claim, wherein said mould tool parts are curved throughout their lengths to provide a hollow curved structure.

9. A composite structure manufactured by the method according to any one of Claims 1 to 8 inclusive.

etching the aluminium mould tool parts from within the formed structure.

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